

The Bureau's Speed Study

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This paper will discuss some of the findings of the Bureau of Public Roads' study of speed related to accidents. In the past, discussions of speed have usually generated considerably more heat than light. One of the difficulties has been that it is not enough to know that a certain number of drivers involved in accidents were traveling at certain speed; it is also essential to determine how much driving was done at that same speed. Then, by relating the travel speeds of accident-involved drivers and all drivers, it is possible to determine the hazard associated with various driving speeds.

Intensive study of speed and other driver and vehicle characteristics was begun in 1957 as a part of a much broader study, undertaken by the bureau in response to a directive of the Congress. The comprehensive study was aimed at determining what Federal action might be feasible to increase highway safety, and findings were reported in the 232-page report transmitted to the Congress in 1959 on "The Federal Role in Highway Safety," House Document No. 93, of the 86th Congress.

The analysis of the data on speed and driver-vehicle factors subsequently has been extended and a research report entitled "Accident Involvements on Main Rural Highways Related to Speed and Characteristics of Drivers and Vehicles," authored by David Solomon of the Bureau's Traffic Systems Research Division, has recently been completed.

Last October, because of widespread interest in the study and its implications for general safety policy and practice, copies of the now completed report were mailed, in rough draft, to 33 individuals, including the heads of principal national safety organizations and agencies. Copies also went to key people in eight universities distinguished for their interest in highway safety and research related thereto.

Among the latter group, quite properly, was Prof. Harold L. Michael of Purdue, who subsequently invited me to discuss some of the significant findings at the 50th Annual Purdue Road School.

Those who reviewed the study report were also invited to meet in bureau headquarters for further briefing on the study by the Bureau's

Office of Research and Development. That meeting, which was held last December, occupied the better part of a full day, and David Solomon, who is responsible for the extensive work performed on the study and the report now in process of publication, was barely able to cover the ground.

Thus, I shall confine myself in this paper to a brief description of what was done and a summary of principal findings.

What Was Done

The bureau made its study of accident involvement related to speed and characteristics of drivers and vehicles in cooperation with 11 states.

In the East: the seaboard states of Connecticut, New Jersey, Virginia, and North Carolina.

In the West: Montana, Oregon, California, and Arizona.

And here in the Midwest: Minnesota, Iowa, and Missouri.

These states were specially selected for two reasons: first, they have superior accident reporting systems; second, they are so located geographically as to make the study data representative of all regions of the country.

The 600 miles of roads for the study also were specially selected in the 11 states as representative of the main rural highways in the United States on which more than a third of all motor vehicle travel occurs.

The study roads consisted of 27 sections of two-lane highways with traffic volumes varying from 1,000 to 8,000 vehicles a day on the average, and eight sections of four-lane divided highways carrying 5,000 to 24,000 vehicles per day.

These 35 study sections were on the average 17 miles long. Except for one section 90 miles long, they varied in length from 5 to 50 miles.

All of the study sections were strictly rural roads. None was located in or at the approach to even a small town. Side interferences thus were minimum—on the average, for each three miles of road there were four intersections and two entrances to roadside businesses. In the selection of the study sections posted speed zones were generally avoided.

On 28 of the sections the daytime passenger-car legal speed limit varied between 55 and 70 miles an hour. Two sections had a 45-mile per hour limit and five others a "reasonable and proper" or similar speed limit. Night speed limits were 5 or 10 miles an hour slower than the daytime limits for about half of the study sections. The remaining sections had identical night and day limits. On eight of the sections both daytime and nighttime speed limits for trucks were lower than for passenger cars, by 5 to 15 miles per hour.

The research involved five steps: determination of average speeds, on-the-site studies, accident-record classification, correlation of results, and analysis.

1. Determination of average speeds. On each of the 35 sections of road a test car carrying a driver-observer-recorder team made several runs over the section of road, moving with the normal flow of traffic and recording speed in each direction at periodic intervals. The recorded speeds were averaged for each interval, a speed profile drawn, and a point selected representative of the average speed for the entire section.

2. On-the-site studies. At the point selected as representative of the average speed for an entire section, speed measurements and interviews were made of individual drivers—290,000 in all—during representative day and night hours, weekdays and weekends, covering all seasons during 1957-8.

Well out of sight of the speed-observation points, the same drivers were interviewed as to age, military status, and residence. Interviewers also noted type of vehicle, model year, make, number of cylinders, body style of passenger car, and seated location of passenger-car occupants. Horsepower of passenger cars was later obtained from automobile manufacturers.

3. Classification of accident records. Accident data for the research were obtained from records of all accidents that had occurred on the 35 study sections and had been reported to state authorities during a period of three or four years ending June 30, 1958. Ten thousand drivers and vehicles were involved. The data included estimated speed prior to the accident; it also included sex of driver, age, etc.—the same information obtained in the roadside interview with non-accident-involved drivers.

Further data on the accidents included the amount of property damage estimated by the police officer, or in some cases by the driver, reporting the accident.

4. Correlation of results. Since the accident data covered a period of three to four years and the interviews and speed measurements only a single 12-month period, the investigators had to utilize volume data for the three- to four-year period. In this way they obtained a basic vehicle-mile estimate toward which the interview data were expanded. They made other adjustments too—taking account, for example, of older cars being scrapped and newer cars entering the market during the various seasons of the year.

5. Analysis. The illustrations in this report document the principal findings of the study. Figure 1 shows the percentage of drivers

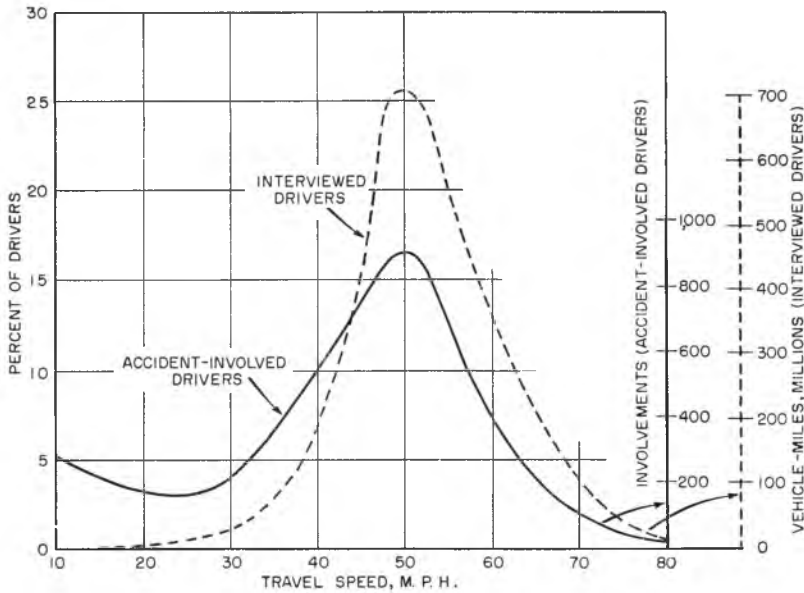


Fig. 1. Percentage of drivers traveling at various speeds.

traveling at various speeds—the solid line representing speed estimates shown in the reports of drivers involved in accidents and the dashed line representing the speeds of the interviewed drivers as actually measured on the highway.

The curves indicate that a larger proportion of accident-involved drivers were traveling at the lower speeds, while in contrast a larger proportion of the interviewed drivers traveled at the higher speeds. For example, 13 percent of the interviewed drivers traveled at 60 miles per hour compared with only 7 percent of the accident-involved drivers. Thus there is an unmistakable indication that low-speed drivers are more likely to be involved in accidents than high-speed drivers, within the limits of the study. It will be noted that at extremely high speed, approaching 80 miles an hour, the difference disappears.

These same curves are also related to the two scales on the right, the solid line showing accident involvements and the dashed line showing vehicle miles of travel as determined by traffic volume counts along the study sections. From this information we calculated the accident-involvement rates shown in Figure 2.

Here then are the accident involvement rates (day and night) on the basis of travel speeds, shown on a log scale. The rates were

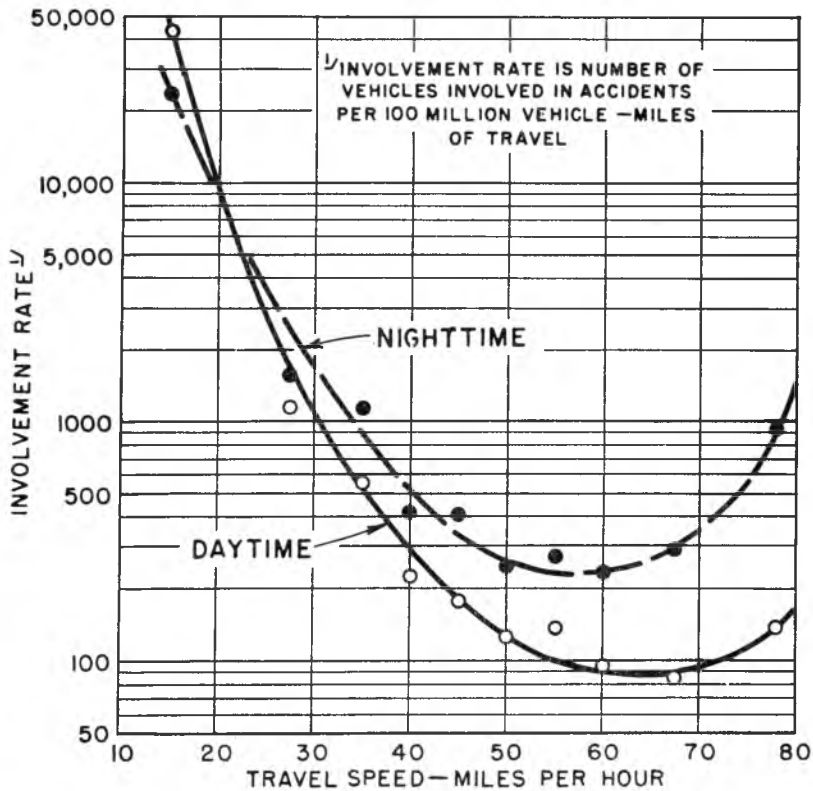


Fig. 2. Involvement rate by travel speed, daytime and nighttime.

derived by dividing the number of accident-involved drivers by the vehicle miles of travel at various speeds.

The involvement rate is in effect a measure of the chance of a driver being involved in an accident at any particular driving speed.

It is evident from the solid line that the daytime involvement rate was highest for the very low-speed drivers, reached a low point at about 65 miles per hour, and increased beyond that speed. A daytime driving speed of 20 miles per hour on main rural highways is about 100 times more likely to result in an accident than a speed of 65 miles per hour.

The dashed curve shows the nighttime involvement rate for various travel speeds. Again, the highest rate was at the very low speeds and the lowest rate at moderately high speed, in this case about 55 miles per hour.

In general, in the range from 20 to 60 miles per hour the night involvement rate was about twice the day rate.

At speeds below 20 miles per hour there was a statistically significant reversal of this trend, with the day rates exceeding the night rates.

At speeds in excess of 60 miles per hour the night rate was several times higher than the day rate.

The sharp upward trend in the night involvement rate at speeds beyond about 65 miles per hour points up the desirability of reducing the upper range of driving speeds at night.

Figure 3 shows involvement rate by variation from average speed—

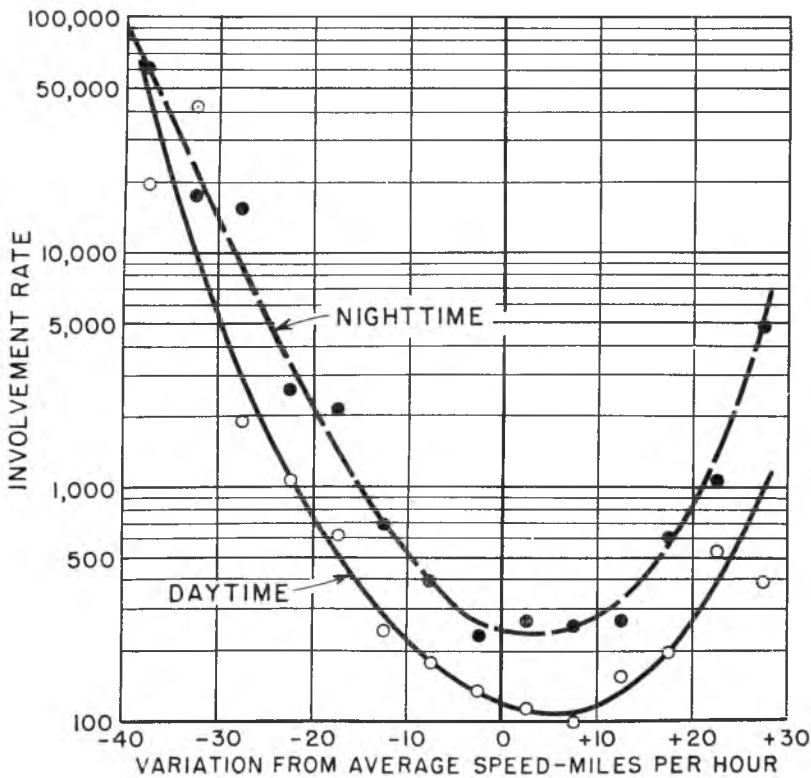


Fig. 3. Involvement rate by variation from average speed of study section, daytime and nighttime.

for both day and night travel. The lowest involvement rate occurred slightly above the average speed as you will see. As speeds departed from the average speed, either higher or lower, the involvement rate increased. This strongly suggests that a reduction in the variation in speeds can reduce accidents substantially. This is perhaps as important as any other single finding obtained on speed from this study.

As is generally supposed, accidents occurring at moderate and high speeds were found to be considerably more severe than accidents which took place at very low speeds. One measure of accident severity is the number of persons fatally or nonfatally injured per 100 accident-involved vehicles.

In Figure 4 you will observe an important hazard associated with

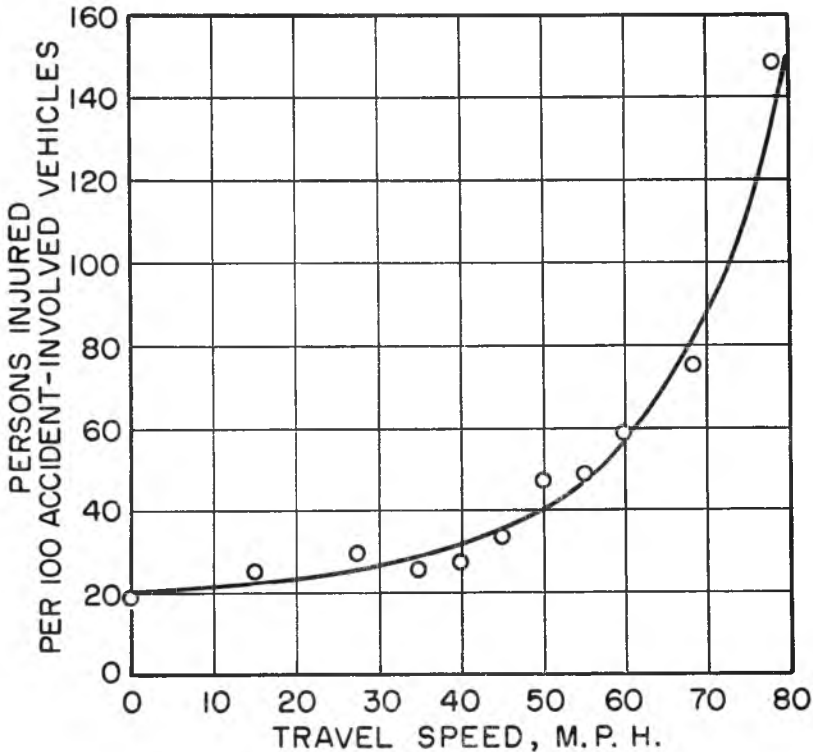


Fig. 4. Persons injured for each 100 vehicles involved in accidents, in relation to speed.

speed. At 40 miles per hour, for example, 31 persons were injured for each 100 vehicles involved in accidents, while at 65 miles per hour there were 70 persons injured for each 100 vehicles involved in accidents.

The relation between speed and accident severity at night was found to be nearly identical to that shown here for daytime conditions.

Property damage also increased with speed but at a somewhat lower rate than the number of persons injured.

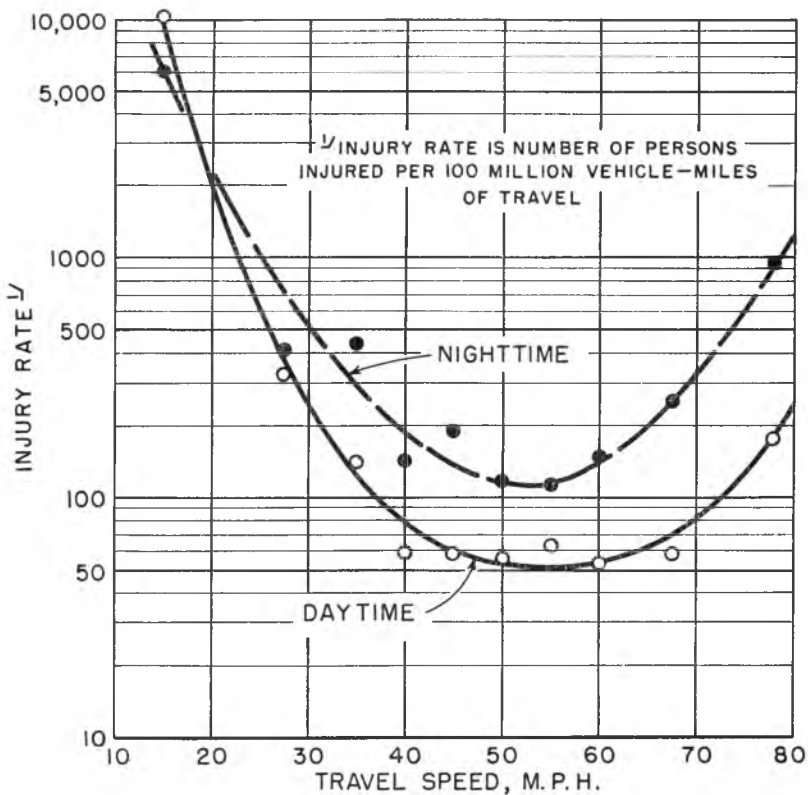


Fig. 5. Injury rate by travel speed, daytime and nighttime.

Figure 5 clearly shows that severity increased rapidly at the higher driving speeds. You will recall that the daytime accident involvement rate also mounted at speeds above 65 miles per hour. As a consequence, as shown here by the solid line, also on log scale, the daytime injury rate—i.e., the number of persons injured per 100 million vehicle-miles of travel—took a sharp upturn beyond speeds of 70 miles per hour. The daytime injury rate showed only small variations between speeds of 40 and 70 miles per hour, but below a speed of 40 miles-per-hour it climbed rapidly, and the highest injury rate was at speeds below 30 miles-per-hour.

At night, the picture was accentuated. Remember the earlier figure—at speeds in excess of 60 miles per hour the ratio of the night-to-day involvement rate climbed sharply. The nighttime injury rate shown here began climbing at a somewhat lower speed than the daytime rate

and at a speed of 80 miles per hour it reached a value five times that of the day injury rate.

The proportion of travel by drivers varied considerably depending upon their age. See Figure 6.

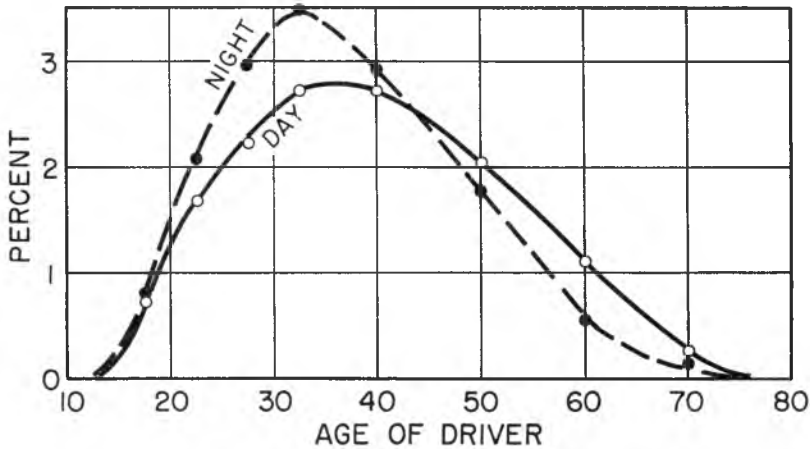


Fig. 6. Percent of travel by age of driver, male and female.

During the daytime, for example, 35-year-old drivers contributed nearly 3 percent of the total vehicle miles of travel. Twenty- and 60-year-old drivers each contributed little more than one percent.

At night the younger drivers increased their proportion of the total travel. Older drivers, particularly those 65 and older, did much less driving.

Particularly noteworthy is the fact that drivers beyond age 65 traveled about two-thirds as much as the average driver in the daytime, but only 17 percent as much at night.

On the average, women drivers accounted for 13 percent of the

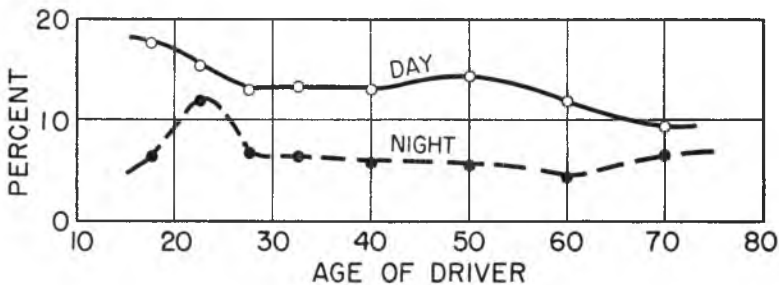


Fig. 7. Percent of travel by female drivers.

daytime vehicle-miles of travel but only 7 percent of the travel during the more critical night hours.

In general, the proportion of women drivers was nearly constant for the various age groups, as shown in Figure 7. One obvious exception is the 20- to 24-year-old female. At night she contributed 12 percent of all travel by drivers of this age group—nearly twice the percentage of any other age group of females at night.

As Figure 8 indicates, both very young and very old drivers had higher involvement rates than drivers of middle age. The exact pattern varied with both sex of driver and day or night conditions. The curves here are based on data for passenger car drivers only.

Male drivers under 20 (the bottom curve, upper left) had the highest daytime involvement rate of any age group.

Male drivers between 30 and 60 years of age had a uniformly low involvement rate, which was less than one-third as great as the under-20 group.

Beyond age 60, the rate increased again.

The pattern for female drivers was similar except that female drivers 70 or over, rather than teenage females, had the highest accident-involvement rate.

At night the accident rate for both males and females was about twice as high as during the daytime. The pattern of involvement rate by age of driver was quite similar to the daytime rate in that those under 20 and those over 60 had the highest involvement rate. However, at night teenage female drivers had a higher involvement rate than teenage male drivers.

It is sometimes suggested that out-of-state drivers have higher involvement rates than local drivers. This study reached the opposite conclusion, however. The daytime involvement rate for local drivers—i.e., drivers residing within the county where the study site was located—had involvement rates nearly twice as great as drivers residing in other counties of the state or out-of-state. At night local drivers had involvement rates more than two and one-half times that of other drivers.

It may be suggested that local drivers have higher involvement rates because they drive at slower speeds. However, the data refute this conclusion. Local drivers generally had involvement rates substantially greater than other drivers regardless of travel speed and day or night conditions. See Figure 9.

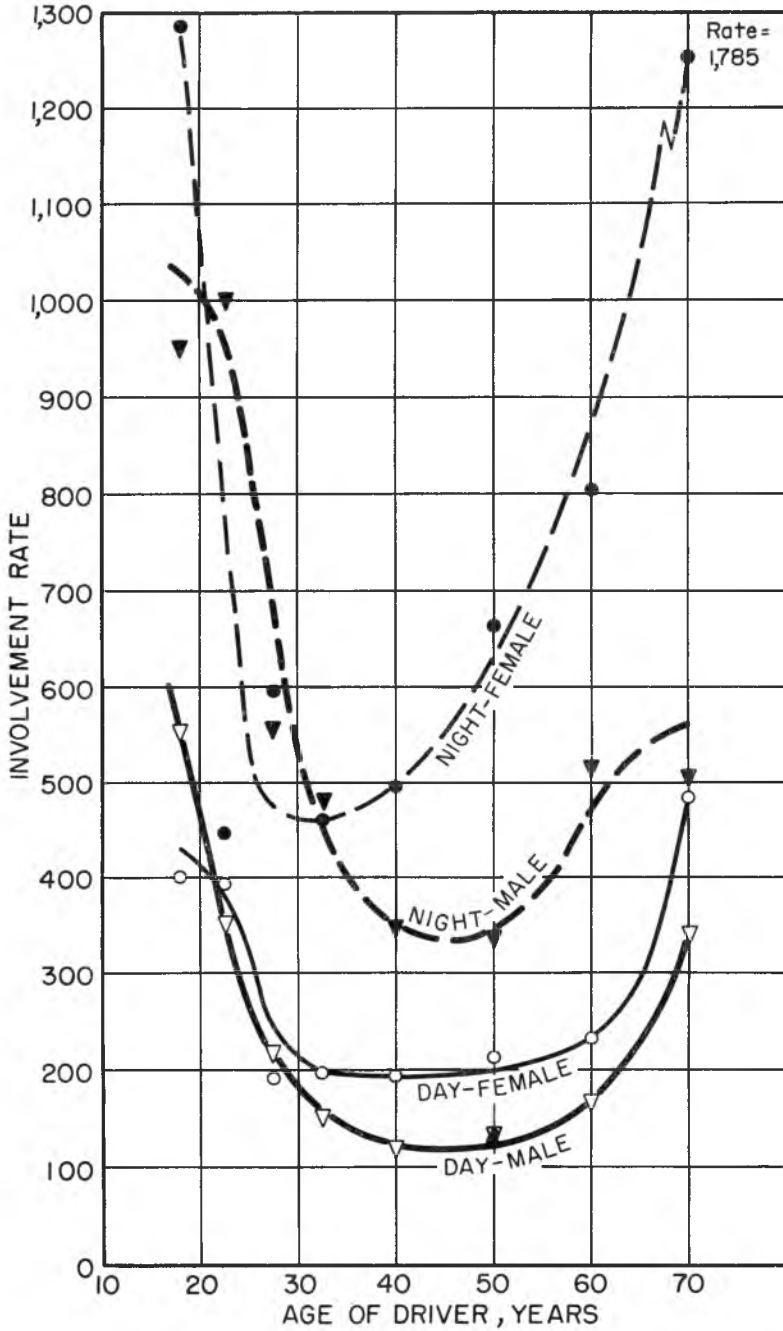


Fig. 8. Involvement rate by sex and age of passenger car driver for night and day conditions.

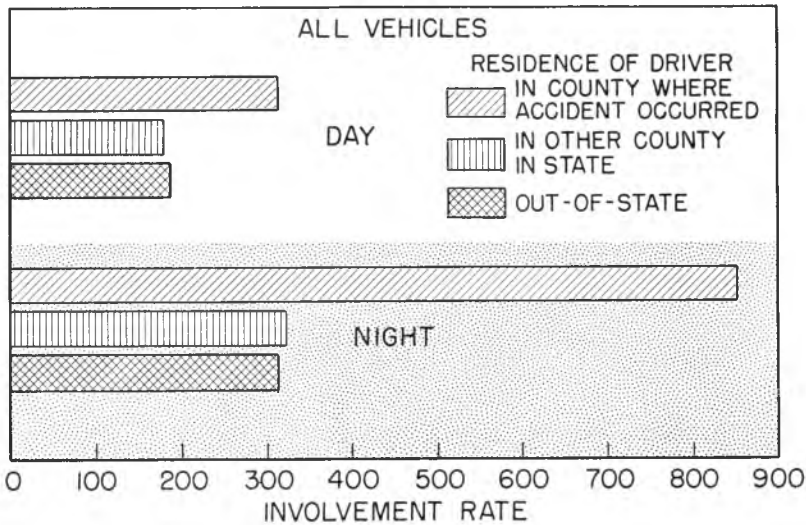


Fig. 9. Involvement rate by residence of driver.

Figure 10 illustrates four types of accident involvements in relation to travel speed.

Rear-end collisions (upper solid line) were the most common type, and the greatest proportion of them occurred at the lower speeds—40 miles per hour or less.

Note the dip in the rear-end collision curve in the speed range of 5 to 25 miles per hour. Note also the upsurge in the angle collisions (the dashed line) in the same speed range. The latter accounts for the former, of course. Five to 25 miles per hour is the speed of many vehicles at crossroads, driveways, and other points of access where angle collisions rise in relation to rear-end accidents.

Head-on collisions—represented by the line near the bottom of the figure—increased linearly with speed, but even at the higher speeds accounted for less than 20 percent of all accident involvements.

The dashed line near the bottom represents single-vehicle, non-collision involvements. Proportionately few at the lower speeds, they increased sharply at speeds in excess of 50 miles per hour.

Above 70 miles per hour these accounted for up to half of all accident involvements.

The pattern for nighttime involvements by travel speed and manner of collision was quite similar to the pattern illustrated here for daytime.

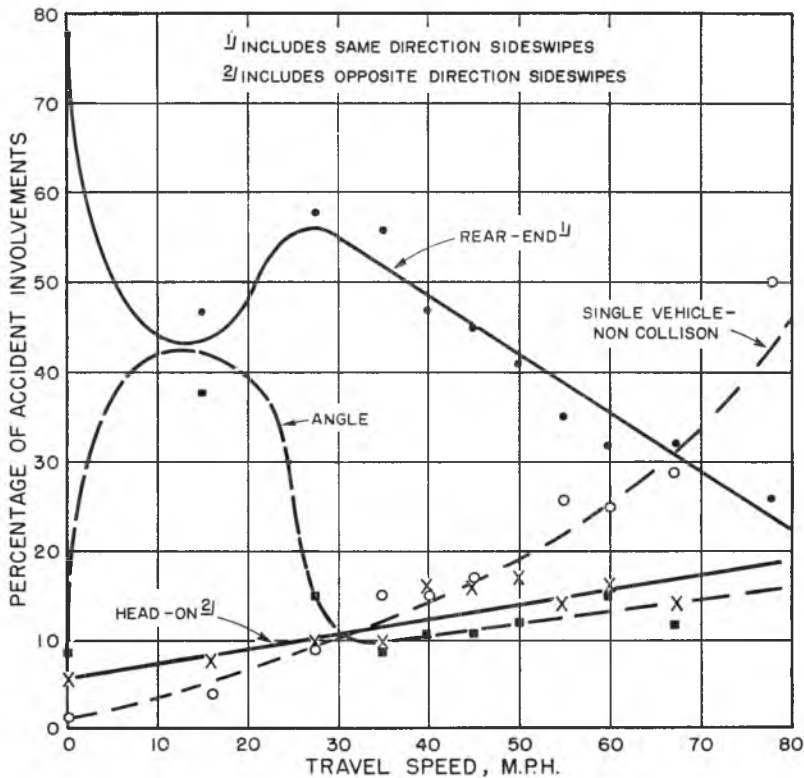


Fig. 10. Percentage of accident involvements by travel speed and manner of collision, daytime—all vehicles.

Figure 11 shows the accident involvement rate by vehicle type. During the daytime the rate was nearly the same for the four principal types of vehicles.

But at night the situation changed radically. The involvement rate for passenger cars was higher than for any other type of vehicle—254 percent higher, for example, than for trucks with 6 or more tires, including combinations. Note that the rates for large trucks and busses were actually lower at night than during daylight hours.

Figure 12 does not support the contention that high horsepower is an important factor in accidents. Rather, the highest involvement rate was that of vehicles with the lowest horsepower—110 or less. This was true during both daytime and nighttime conditions, as shown here, and regardless of travel speed and other driver and vehicle characteristics, the involvement rate showed little variation among the higher horsepower groups.

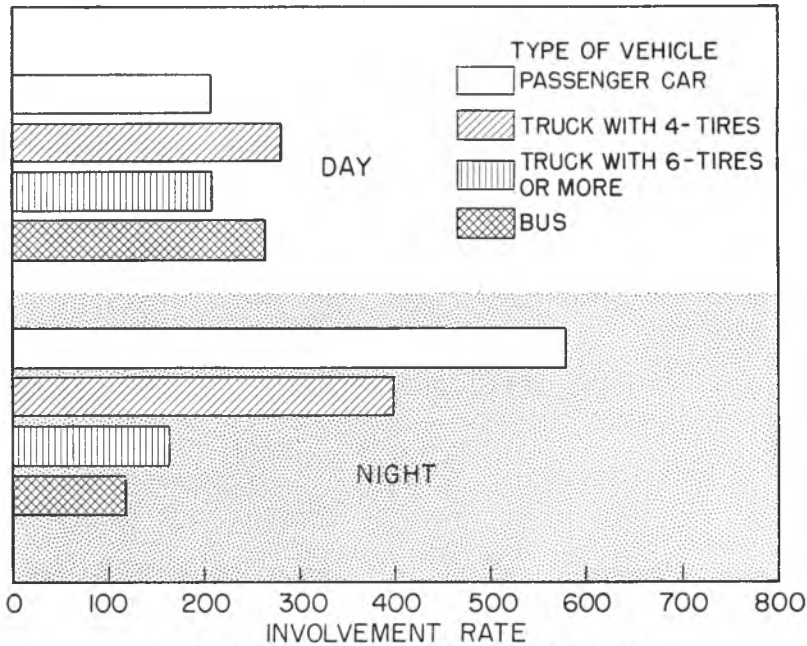


Fig. 11. Involvement rate by type of vehicle.

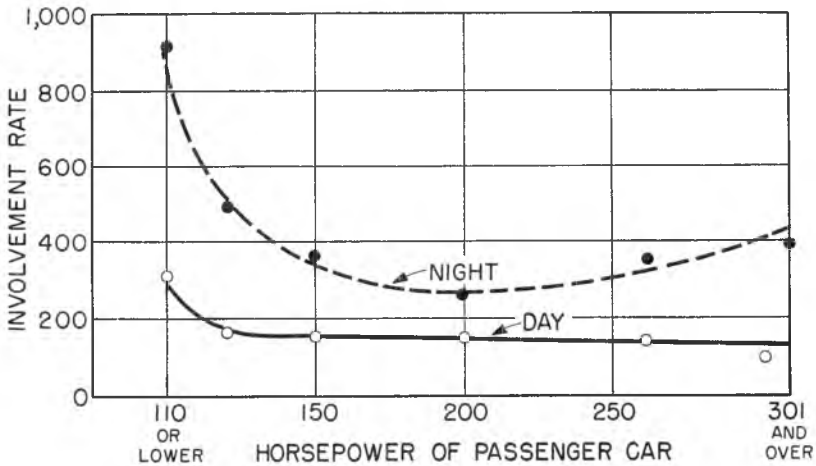


Fig. 12. Involvement rate by horsepower of passenger car.

The seated position of passenger car occupants had a substantial effect upon the probability of their being injured or killed in an accident.

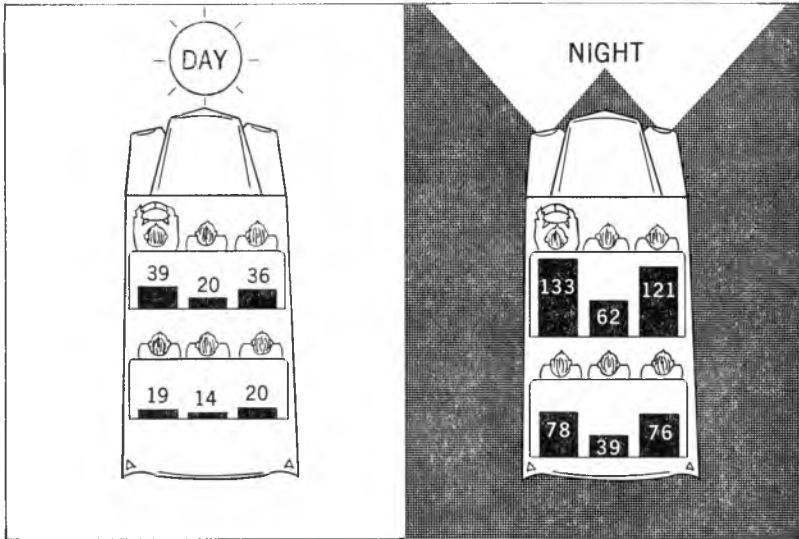


Fig. 13. Occupant-mile injury rates by seated position.

Figure 13 shows that the number of car occupants injured per 100 million vehicle-miles of travel was greatest in the left and right front seats compared to the other seated positions.

The injury rate was about half as great for the occupants of the center front, left rear, and right rear seats.

It was least for occupants of the center rear seat.

The pattern was similar for both day and night conditions, although nighttime rates are much higher.

Day or night, in fatal accidents, the left and right front seats were also significantly more hazardous than other seated locations.

The Cornell Crash Injury Research produced similar results, though the findings are not directly comparable.

SUMMARY

The principal findings of this study in relation to reported accidents on two- and four-lane main rural highways (not freeways) are summarized in the following statements.

1. The accident involvement, injury, and property damage rates were highest at very low speeds, lowest at about the average speed of all traffic, and increased at the very high speeds, particularly at night. Thus, the greater the variation in speed of any vehicle from the aver-

age speed of all traffic, the greater its chance of being involved in an accident.

2. The severity of accidents increased as speed increased, especially at speeds exceeding 60 miles per hour.

3. The fatality rate was highest at very high speeds and lowest at about the average speed.

4. Passenger-car drivers under 25 years of age and more than 65 years of age had the highest involvement rates.

5. Women passenger-car drivers over 35 years of age consistently had higher accident involvement rates than male drivers.

6. Local drivers tended to have higher involvement rates than other drivers, particularly at night.

7. During the day, for passenger cars and trucks, only small differences existed in involvement rates. However, at night, passenger car involvement rates were nearly three times as great as those for trucks having six or more tires.

8. Drivers of passenger cars having low horsepower had higher involvement rates than drivers of cars having higher horsepower, regardless of the variables studied.

9. The range in involvement rates was considerable; the rate depending on the combinations of driver and vehicle characteristics studied. I want to emphasize that findings are averages for specific driver groups, are not applicable to individual drivers, and do not prove that individual identifiable drivers are accident prone. The findings in the study reported here do show that as a group some specific classes of drivers are more likely to be involved in accidents than other classes of drivers. Very slow speeds, and to a lesser extent, youth, had the greatest effect on the involvement rate.

10. Computation of injury rates on an occupant-mile basis showed the highest injury rate for occupants of the front left and right seats. The injury rate was about one-half as great for occupants of the center front and left and right rear seats, and one-third as great for occupants of the center rear seat.

11. Nearly half of all accident involvements were either rear-end collisions or same direction sideswipes. However, the proportion of these accident involvements decreased as travel speed increased. Single vehicle, noncollision accident involvements contributed an increasingly greater proportion of all accidents as speed increased, particularly at speeds greater than 70 miles per hour. At speeds of 80 miles per hour noncollision accidents constituted half of all involvements. Although angle

collisions usually were less than 15 percent of the total, at speeds below 25 miles per hour they constituted more than one-third of all accident involvements. The proportion of head-on collisions or opposite-direction sideswipes increased as speed increased. But this type of accident (involvement) always was less than 20 percent of the total, regardless of speed and day or night conditions.

12. Variations from the average driving speed, either faster or slower, are associated with a higher accident involvement rate. From the findings of this study it appears that, on rural highways at least, even the lowest speed can be hazardous when adverse conditions exist, and high speeds can be safe when circumstances are favorable.

When the completed report on this important study is available, it should be examined in more detail for its value to your future safety practices and programs.